Profiling Dissipation Measurements using χpods on Moored Profilers in Luzon Strait

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LONG-TERM GOALS

The long-term goal of this program is to understand the physics of small-scale oceanic processes and how they affect the larger scales of ocean circulation. Ongoing studies within the **Ocean Mixing Group** at OSU emphasize observations, interaction with turbulence modelers and an aggressive program of sensor / instrumentation development and integration.

OBJECTIVES

The principal objectives of this project are to:

- quantify the energy losses to turbulent dissipation in the Luzon Strait in a systematic, comprehensive and extended way;
- quantify the spring-neap variation in these energy losses;
- assess whether turbulence is driven primarily by diurnal, semidiurnal, near-inertial, or mesoscale shear;
- obtain meaningful, long-term observations of turbulent heat and momentum flux profiles in Luzon Strait, from which useful parameterizations may be derived;
- measure the seafloor pressure difference through the Strait associated with deepwater overflows.

APPROACH

To accomplish these objectives, we will:

1. modify 2 McLane Moored Profilers MPs for direct and extended measurements of turbulence,
2. build additional fixed-point turbulence measurements to add to the MP moorings, and
3. contribute high-resolution seafloor pressure sensors for mooring-of-opportunity deployments.

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WORK COMPLETED

Initial engineering tests were conducted in Puget Sound, December 2009. These tests were coordinated with an independent study of form drag over Three Tree Point south of Seattle. A modified MP (similar to that shown in Fig. 1) was deployed for 3 days. These data revealed low-level contamination in high-frequency temperature gradient measurements. Subsequent lab tests showed these to be due to a flaw in construction that has been rectified. Rev2 was deployed in Luzon Strait by Nash and APL personnel during the August 2010 IWISE pilot (at mooring location MPN). As well, χpods (Moum and Nash, 2009) were deployed above and below the profiling range of the MP.

A second MP is now in the lab being modified for the main IWISE deployments in 2011.

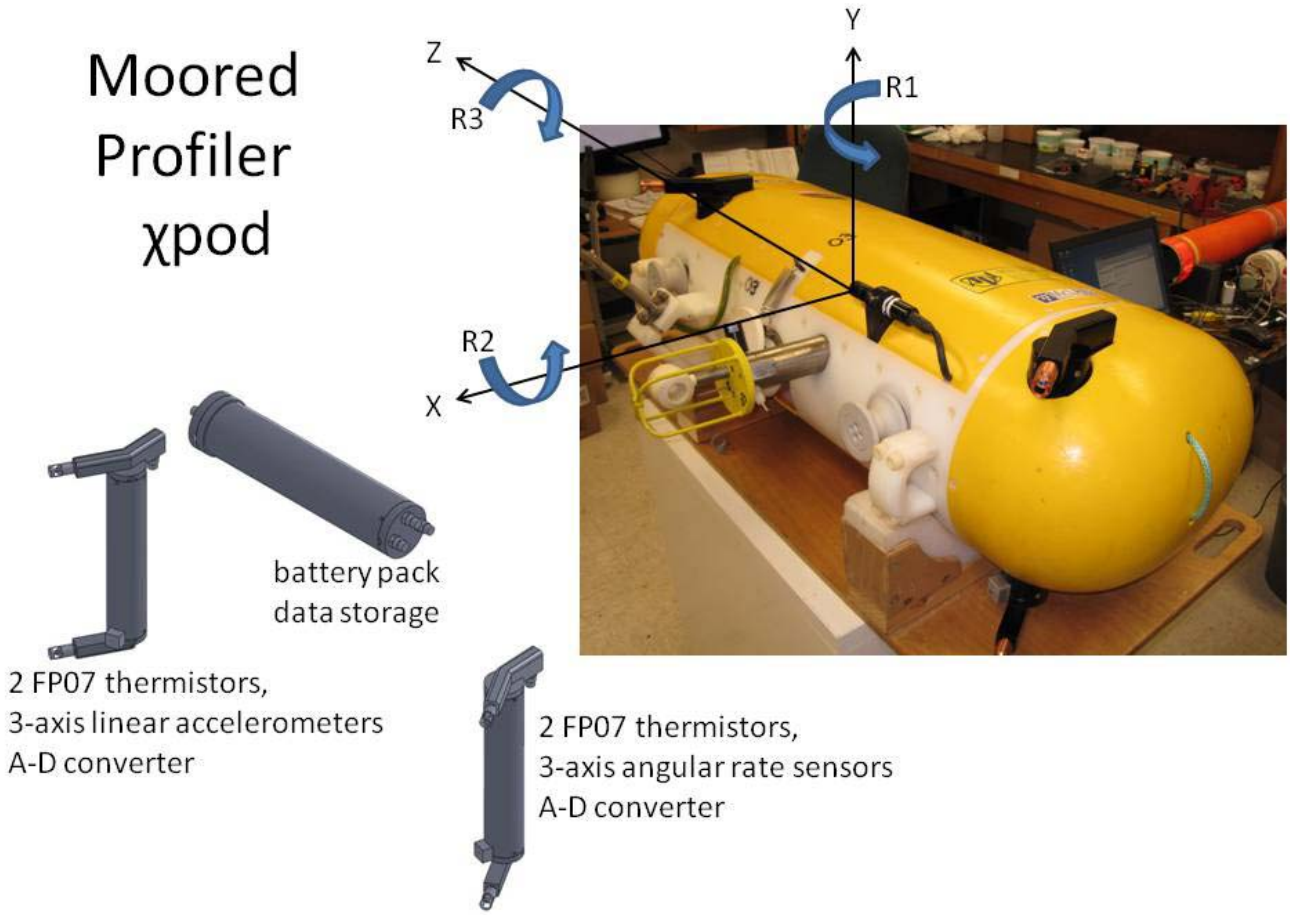

Figure 1 – Photograph and schematic of turbulence sensors on an APL Moored Profiler as configured for IWISE 2010 pilot. Three separate pressure cases house i) upper thermistor pair + linear accelerometers ii) lower thermistor pair + angular rate sensors, each with its own analog-to-digital converter and iii) battery pack and data storage unit. All data sampled at 100 Hz. Copper sensor stings are visible in the photograph. Pressure cases are covered by the yellow skin of the MP.

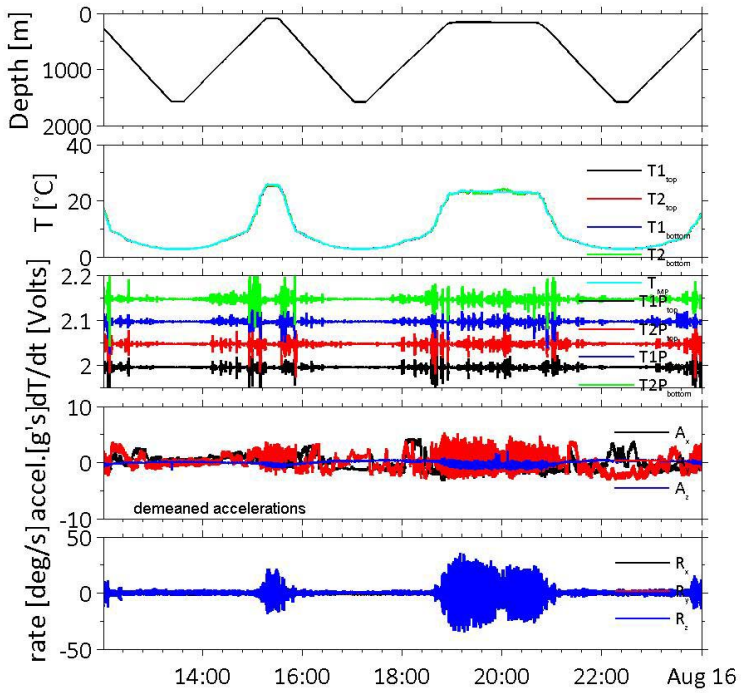

Figure 2– Sample 12h record from MP χpod sensors in Luzon Strait (August 2010). Upper panel indicates the profiling depth range (100 – 1600 m); 2nd panel - temperature from 4 fast thermistors plus slow YSI sensor; 3rd panel - records of dT/dt indicating the small-scale temperature gradients due to turbulent fluctuations; 4th panel – linear accelerations in 3 orthogonal coordinate directions oriented in the MP reference frame as in Fig. 1; bottom panel – angular rates in 3 orthogonal coordinate directions, dominated by rotations about the cable at the upper stop.

RESULTS

MPN was recovered on Sept 6, 2010 and a subset of MP χpod data was downloaded immediately upon recovery. These indicate a successful deployment. Data samples are shown in Figs. 2,3.

There exists occasional contamination of lower thermistors on UP profiles and of upper thermistors on DOWN profiles, thus justifying our effort in manufacturing this particular configuration. For analysis of turbulence quantities (Moum and Nash, 2009) we plan to systematically choose the upstream sensors.

A12h data sample is shown in Fig.2 as a time series. The MP profiles from about 100 m to 1600 m depth. The 5 temperature records (1 MP YSI sensor, 2 fast upper sensors, 2 fast lower sensors) show the gross temperature structure as the MP profiles through the water column. Intensely-fluctuating temperature gradient signals (dT/dt) indicate regions of strong turbulence. These regions include:

1) the upper part of the water column where currents (and current shears) are large at this location;
2) intermittent patches in the interior highlighted by the example detailed in Fig. 3; and

3) the upper stop point. Here, the MP stops for a period of 15 minutes to several hours. Accelerations (both linear and angular rates) are large and dominated by surface wave frequencies, presumably transmitted by buoyancy elements above in the water column.

In sum, the χ measurements from the upstream sensors (those pointed into the flow) appear to be "clean" while the MP is profiling and are unaffected by MP motion. A full analysis awaits return of the physical unit to our lab.

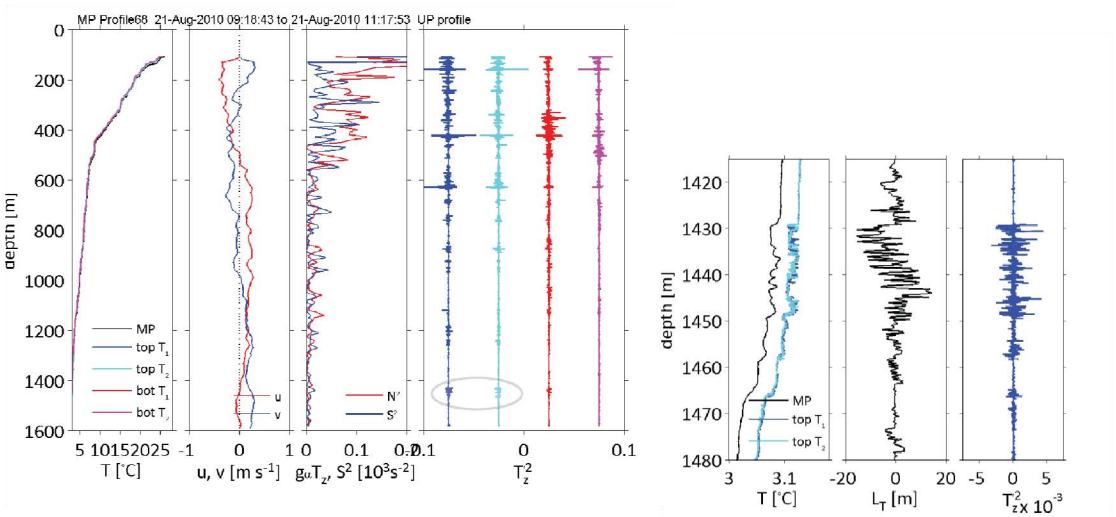

Figure 3 – Example profile with detail of overturn at 1440 m depth. High frequency temperatures detected by the upper 2 fast thermistors from this UP profile show details not measured by the slow YSI sensor. Thorpe scales show 15-20 m overturns. Temperature gradient fluctuations will be spectrally-scaled to estimate temperature variance dissipation rate (χ_T), turbulence diffusivity (K_T) and turbulence kinetic energy dissipation rate (ε_χ).

RELATED PROJECTS

This work is being done in collaboration with M. Alford (APL/UW), who operates the MPs that we have modified.

REFERENCES

Moum, J.N. and J.D. Nash, 2009. Mixing measurements on an equatorial ocean mooring, *J. Atmos. and Oceanic Tech.*, 26, 317-336.